a branch line connected to said economizer and extending into said compressor;

water passing through said chiller in a heat exchange relationship and being cooled;

said compressor being unloaded solely by regulating the speed of said compressor;

motor means for driving said compressor;

means for varying the speed of said motor means by controlling the frequency of electric current supplied to said motor;

means for providing cooling to said means for varying the speed;

means for sensing the temperature of water leaving said chiller;

means for controlling said means for varying the speed responsive to the sensed temperature of water leaving said chiller.

24. (New) The refrigeration system of claim 23 wherein liquid refrigerant from said condenser is supplied by said means for providing cooling to said means for varying the speed of said motor.

25. (New) The refrigeration system of claim 23 wherein said means for varying the speed of said motor has a constant output over a range of frequency and voltage inputs.

means for controlling said means for varying the speed responsive to the sensed temperature of water leaving said chiller.

19. (New) The refrigeration system of claim 18 wherein liquid refrigerant from said condenser is supplied by said means for providing cooling to said means for varying the speed of said motor.

20. (New) The refrigeration system of claim 19 wherein liquid refrigerant used to provide cooling to said means for varying the speed is at least partially evaporated and supplied to said chiller.

21. (New) The refrigeration system of claim 18 wherein said means for controlling said means for varying the speed acts solely responsive to the sensed temperature of water leaving said chiller.

22. (New) The refrigeration system of claim 18 wherein said means for varying the speed of said motor has a constant output over a range of frequency and voltage inputs.

23. (New) A refrigeration system having:

a closed fluid circuit serially including a compressor, a discharge line, a condenser, a first expansion device, an economizer, a second expansion device, a chiller and a suction line leading back to said compressor;

In the FIGURE, the numeral 10 generally designates a refrigeration system. Refrigeration system 10 has a screw compressor 12 which has no mechanical unloading structure. Refrigeration system 10 includes a closed fluid circuit serially including compressor 12, discharge line 14, condenser 16, line 18 containing expansion device 20 and flash tank economizer 22, line 24 containing expansion device 26, chiller 28 and suction line 30. Line 32 branches from flash tank economizer 22 and provides fluid communication with a trapped volume in compressor 12 at an intermediate pressure.

Compressor 12 is driven by motor 11 under the control of variable speed drive 40 which is connected to the electrical power grid (not illustrated). Variable speed drive 40 controls the alternating frequency of the current supplied to motor 11 thereby controlling the speed of motor 11 and the output of compressor 12. In chiller 28, water is chilled by refrigerant circulating in the closed fluid circuit of refrigeration system 10. The chilled water provides the cooling to the zones. The temperature of the water leaving chiller 28 via line 29 is sensed by thermal sensor 50 and supplied to microprocessor 100. Microprocessor 100 controls variable speed drive 40 and thereby motor 11 and compressor 12 to maintain a desired water temperature for the water leaving chiller 28. Microprocessor 100 can control variable speed drive 40 solely responsive to the temperature sensed by thermal sensor 50 or it may also receive zone inputs from the zones being cooled and regulate the rate of water circulation through the chiller 26, and thereby the amount of available cooling. If desired, microprocessor 100 may also control expansion devices 20 and 26.

While refrigeration system 10, as described above, has many features common with conventional refrigeration systems, there are a number of significant differences. Screw compressor 12 is simpler than conventional refrigeration compressors in that it has no mechanical unloading structure. Accordingly, the rotors only seal with each other and the bores. There is no slide valve which replaces portions of the bores in the region of a cusp with the attendant extra manufacturing costs and potential for leakage between the slide valve and adjacent structure or any other mechanical unloading structure. The output of compressor 12 is controlled through motor 11 whose speed is controlled by variable speed drive 40. The motor 11 is matched to the variable speed drive 40 and compressor 12. There is an ideal compressor speed for the design compressor output. So the motor is chosen to have efficient operation at the ideal compressor speed and to have an optimized power factor. On the input side of the variable speed drive, a near unity power factor reduces energy usage and the cost of the energy because of the reduced energy demand at, or approaching, unity power factor. This is because the power factor of the variable speed drive, not the power factor of the motor, is seen by the utility, since the variable speed drive isolates the motor from the utility.

In the operation of refrigeration system 10, gaseous refrigerant is induced into compressor 12 via suction line 30 and compressed with the resultant hot, high pressure refrigerant gas being supplied via discharge line 14 to condenser 16. In condenser 16, the gaseous refrigerant condenses as it gives up heat due to heat transfer via air, water or brine-cooled heat exchangers (not illustrated). The condensed refrigerant passes from condenser 16 into line 18 and serially passes through expansion device 20 into flash tank economizer 22. A portion of the refrigerant flowing into economizer 22 is diverted into line 32 at an intermediate pressure and passes via line 32 to a trapped volume in compressor 12. The remaining liquid refrigerant in economizer 22 passes through expansion device 26 thereby undergoing a pressure drop and partially flashing as it passes via line 24 into chiller 28. In chiller 28, the remaining liquid refrigerant evaporates due to heat transfer to the water passing through chiller 28 via line 29. The economizer flow into compressor 12 via line 32 increases the capacity of compressor in that it increases the mass of refrigerant gas being compressed.

Microprocessor 100 receives a signal form thermal sensor 50 indicative of the temperature of the water leaving chiller 28 via line 29 to provide cooling to one or more zones (not illustrated). Responsive to the water temperature sensed by sensor 50, the microprocessor 100 sends a signal to variable speed drive 40 to cause it to change the speed of motor 11 to increase or decrease the cooling capacity of compressor 12, as required. Variable speed drive 40 increases or decreases the speed, and therefore the capacity, of compressor 12 by changing the frequency of the current supplied to power motor 11. By having a motor 11 operating at an optimum power factor the electrical usage and demand are minimized and the size of the variable speed drive 40 required is reduced. Additionally, a portion of the liquid refrigerant in condenser 16 is diverted via line 17 to the variable speed drive 40 where the electronic components are cooled and the refrigerant evaporated. The evaporated refrigerant passes from variable speed drive 40 via line 41 to chiller 28. The rate of flow of refrigerant to variable speed drive 40 from condenser 16 is controlled by valve 42 responsive to the temperature of the refrigerant leaving variable speed drive sensed by sensor 43. Because the variable speed drive 40 is cooled by the liquid refrigerant, a still smaller variable speed drive 40 can be used.

Although a preferred embodiment of the present invention has been illustrated and described, other changes will occur to those skilled in the art. For example, the economizer may be omitted and/or zone temperature, water flow rates, the expansion devices can be connected to the microprocessor. It is therefore intended that the present invention is to be limited only by the scope of the appended claims.

What is claimed is:

1. A refrigeration system having:

- a closed fluid circuit serially including a screw compressor, a discharge line, a condenser, an expansion device, a chiller and a suction line leading back to said compressor;
- water passing through said chiller in a heat exchange relationship and being cooled;
- said compressor being unloaded solely by regulating the speed of said compressor;
- motor means for driving said compressor;
- means for varying the speed of said motor means by controlling the frequency of electrical current supplied to said motor;
- means for providing cooling to said means for varying the speed;
- means for sensing the temperature of water leaving said chiller;
- means for controlling said means for varying the speed responsive to the sensed temperature of water leaving said chiller.

2. The refrigeration system of claim 1 wherein liquid refrigerant from said condenser is supplied by said means for providing cooling to said means for varying the speed of said motor.

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3. The refrigeration system of claim 2 wherein liquid refrigerant used to provide cooling to said means for varying the speed is at least partially evaporated and supplied to said chiller.

4. The refrigeration system of claim 1 wherein said means for controlling said means for varying the speed acts solely responsive to the sensed temperature of water leaving said chiller.

5. The refrigeration system of claim 1 wherein said means for varying the speed of said motor has a constant output over a range of frequency and voltage inputs.

6. A refrigeration system having:

a closed fluid circuit serially including a screw compressor, a discharge line,

a condenser, a first expansion device, an economizer, a second expansion device, a chiller and a suction line leading back to said compressor;

a branch line connected to said economizer and extending into said compressor;

water passing through said chiller in a heat exchange relationship and being cooled;

said compressor being unloaded solely by regulating the speed of said compressor;

motor means for driving said compressor;

means for varying the speed of said motor means by controlling the frequency of electric current supplied to said motor;

means for providing cooling to said means for varying the speed;

means for sensing the temperature of water leaving said chiller;

means for controlling said means for varying the speed responsive to the sensed temperature of water leaving said chiller.

7. The refrigeration system of claim 6 wherein liquid refrigerant from said condenser is supplied by said means for providing cooling to said means for varying the speed of said motor.

8. The refrigeration system of claim 6 wherein said means for varying the speed of said motor has a constant output over a range of frequency and voltage inputs.

9. A method for selecting the compressor, motor and variable speed drive for refrigeration system comprising the steps of:

for a given design refrigeration requirement, selecting a compressor having a design speed and being capable of providing the necessary refrigerant delivery;

selecting a motor operating at the compressor design speed with a power factor of at least 0.89 when delivering the design amount of refrigerant;

selecting a variable speed drive for controlling said motor by varying the frequency of electric power supplied to said motor such that said variable speed drive operates at an input power factor of at least 0.99 when driving said motor to drive said compressor to deliver the design amount of refrigerant.

10. The method of claim 9 wherein the step of selecting a compressor includes the selection of a compressor without mechanical unloading structure.

11. The refrigeration system of claim 3 wherein said motor means has a power factor of at least 0.89 and said means for varying the speed of said motor means varies the frequency of electric power supplied to said motor means such that said means for varying the speed of said motor means operates at an input power factor of at least 0.99 when driving said motor means.

12. The refrigeration system of claim 4 wherein said motor means has a power factor of at least 0.89 and said means for varying the speed of said motor means varies the frequency of electric power supplied to said motor means such that said means for varying the speed of said motor means operates at an input power factor of at least 0.99 when driving said motor means.

13. The refrigeration system of claim 5 wherein said motor means has a power factor of at least 0.89 and said means for varying the speed of said motor means varies the frequency of electric power supplied to said motor means such that said means for varying the speed of said motor means operates at an input power factor of at least 0.99 when driving said motor means.

14. The refrigeration system of claim 7 wherein said motor means has a power factor of at least 0.89 and said means for varying the speed of said motor means operates at an input power factor of at least 0.99 when driving said motor means.

15. The refrigeration system of claim 8 wherein said motor means has a power factor of at least 0.89 and said means for varying the speed of said motor means operates at an input power factor of at least 0.99 when driving said motor means.

16. The method of claim 10 further including the step of selecting means for cooling said variable speed drive with refrigerant from said refrigeration system.

17. The method of claim 16 further including the steps of:

selecting means for sensing the temperature of water leaving the chiller; and

selecting means for controlling the speed of said motor solely responsive to the sensed temperature of the water leaving the chiller.

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